

Identifying research priorities for the competitiveness of arable crops

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Abstract. *EU agriculture and arable crops in particular are suffering from competitiveness deficits compared to other producers in the world economy. One potential strategy to cope with competitiveness challenges is to focus on research and technological innovation. The objective of this paper is to present the results of the project EUROCCROP (Agricultural research for improving arable crop competitiveness – EUROCCROP - <http://www.euroccrop.cetiom.fr/>), aimed at the identification of research priorities for arable crop competitiveness. The project adopts a definition of competitiveness based on a combination of economic competitiveness and social/environmental sustainability. Furthermore, the project utilises both a crop chain and a horizontal issue perspective, and develops research priorities through the interaction of the scientific level (expert group approach) and the stakeholder level (scenario analysis). The main result of the project is the elaboration of approximately eighty research topics. Among these, the main areas for research identified are A: Risk management and adaptation of arable farming; B: Innovation in cropping systems for high environmental and economic performances; C: Limiting the impact of arable crop cropping systems on green-house gas emissions; D: Better understanding of public concern about arable crop production and products and communication with global and local societies. The project confirms that a number of well established research topics retain their importance (e.g. yield improvement, plant protection). However, they require cautious coordination with an increasingly complex system of short term priorities.*

Keywords:..Arable crops, crop chain, competitiveness, research priorities, foresight,

1. Introduction and objectives

Arable crops (AC) cover 40% of the European Union's utilised agricultural area, and are found in all the Member States. In economic terms, AC are one of the main sectors of European agriculture, with about 10,7% of total agricultural output value and about 20% of the value of crop production. Within the sector, cereals, with 9,2% of output value of crop production and about 270 million tonnes in 2006, represent by far the main category. Though distributed in all countries, France and Germany are by large the main producers with respectively 60 and 40 million tonnes. For their wide cultivation, AC play also a major role in all issues concerning agriculture and environment, both in terms of adaptation of agriculture to different economic systems and in terms of impacts on the environment and the landscape by agriculture. EU agriculture and arable crops in particular are suffering from competitiveness deficits compared to other producers in the world economy. The process of decoupling of the Common Agricultural Policy (CAP), strengthening the market orientation of the system, and market trends in 2007 and 2008, with increased price volatility of agricultural products, have further driven the agenda towards higher interest for improving efficiency and productivity. Furthermore, EU agriculture is submitted to strong compliance conditions, progressively enforced through regulations, which arguably constitute one of the causes of its competitiveness deficit in the world economy, but can be also seen as a condition of “societal” legitimacy and hence contribute to competitiveness through social acceptability in the EU.

One key strategy to cope with competitiveness challenges in the present economic context is to focus on research and technological innovation. The objective of this paper is to present the main results of the project EUROCCROP (Agricultural research for improving arable crop competitiveness – <http://www.euroccrop.cetiom.fr/>), aimed at the identification of research priorities for arable crop competitiveness. A full account of the project outcomes is available in Pilorgé (2009) [4].

The paper is organised in three main sections. Section 2 presents the methodology for identification of research priorities. Section 3 presents the main results of this exercise. A discussion follows in section 4. The paper ends with conclusion in section 5.

2. Methodology

2.1. Definition of competitiveness

The starting point of the methodology is the agreement about a definition of competitiveness for arable crop. The first reference considered is a classical definition of economic competitiveness as interpreted by Porter's model. Such model considers five major forces which are exerted on a company or a sector, respectively the powers of the supply sector (1), of the other producers in foreign countries (2), of the customers (3), of the substitution products (4) and of the regulations (5), and at last the internal competition within the system (0) (Porter 1980) [5].

However, the objectives and the object of the project itself lead to consider an even wider approach of competitiveness, with a combination of economic competitiveness and social/environmental sustainability.

EUROCROP distinguishes two main levels of competitiveness:

→ Economic competitiveness, which refers to a more or less short/medium term approach, with two sub-themes:

- Economic competitiveness of AC at the farm level in EU countries (a crop versus other crops, arable crops versus other land uses) assuming the respect of current regulations when enforced.
- Economic competitiveness of EU arable crops in markets: meeting industry and consumer demand (with respect to quantity, quality, specifications, regularity of production, prices...)

→ Sustainability and cross compliance which constitute a medium term/long term approach and rests upon assessment through indicators. This theme focuses on meeting society needs, with greater attention to social and environmental issues.

2.2. General project organization and workflow

The project utilises both a crop chain and a horizontal issue perspective: EUROCROP considers 8 arable crop chains, which receive subsidies under the EU Common Agricultural Policies: Cereals (major and secondary), oilseed crops, sugar beet, fibre crops, potatoes, legume crops, and maize (Figure 1).

More widely, it also considers arable crop farming systems in their regional and global contexts.

Arable crop chains may be considered as value chains whose activity presents positive or negative impacts on horizontal categories which correspond to societal concerns and involve major stakeholders' groups.

EUROCROP brought together concerned stakeholders and actors, to reach a collective analysis through the elaboration of scenarios and the definition of main stakes and challenges for the arable crop sector. The EUROCROP partnership includes organisations using research, including farmers' organisations, and organisations providing research, innovation and extension services. Stakeholders and representative civil society organizations in the field of environment conservation and consumer advocacy are integrated in the partnership of the project, and were particularly involved in the Project Advisory Committee (PADCO).

The structure of the partnership and the project organisation were designed to deal with the necessary connexions and interactions between research, knowledge, innovation and socio-economic actors (including research institutions) strategies.

Furthermore, the project developed research priorities through the interaction of the scientific level (based on an expert group approach) and the stakeholder level (based on a scenario analysis) (Figure 2).

The general methodology of the project was adapted from the CNAM strategic foresight methods [1], [2]

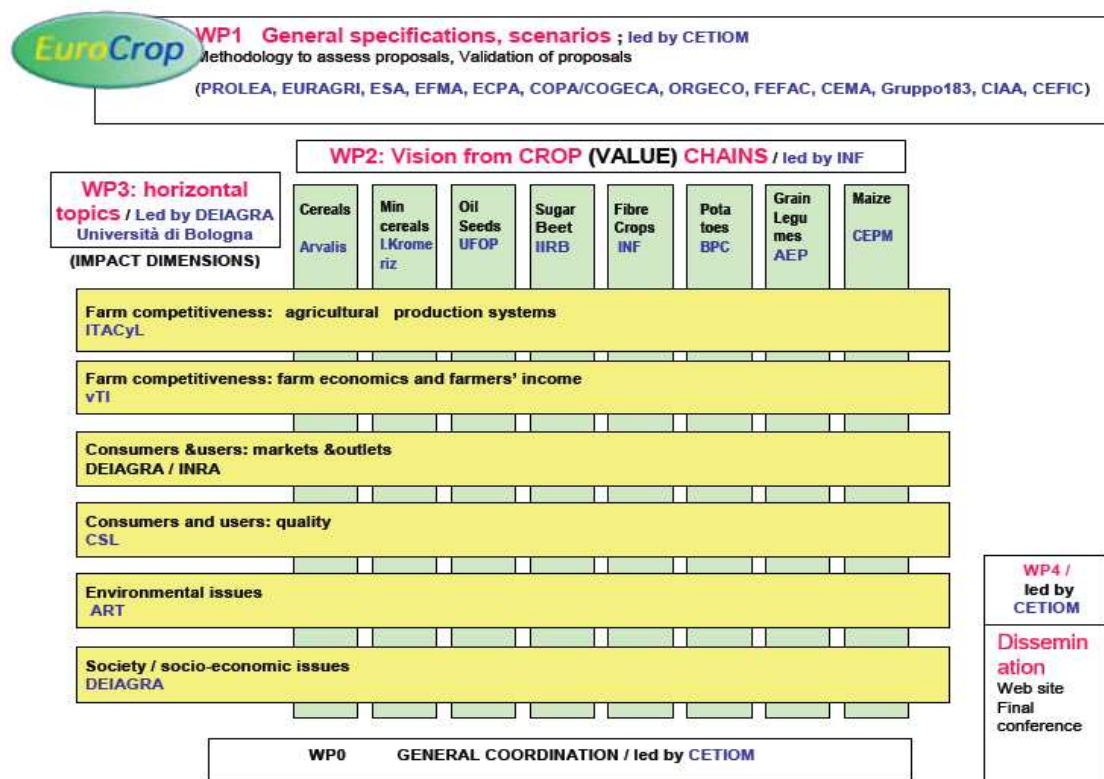


Figure 1: Project organisation

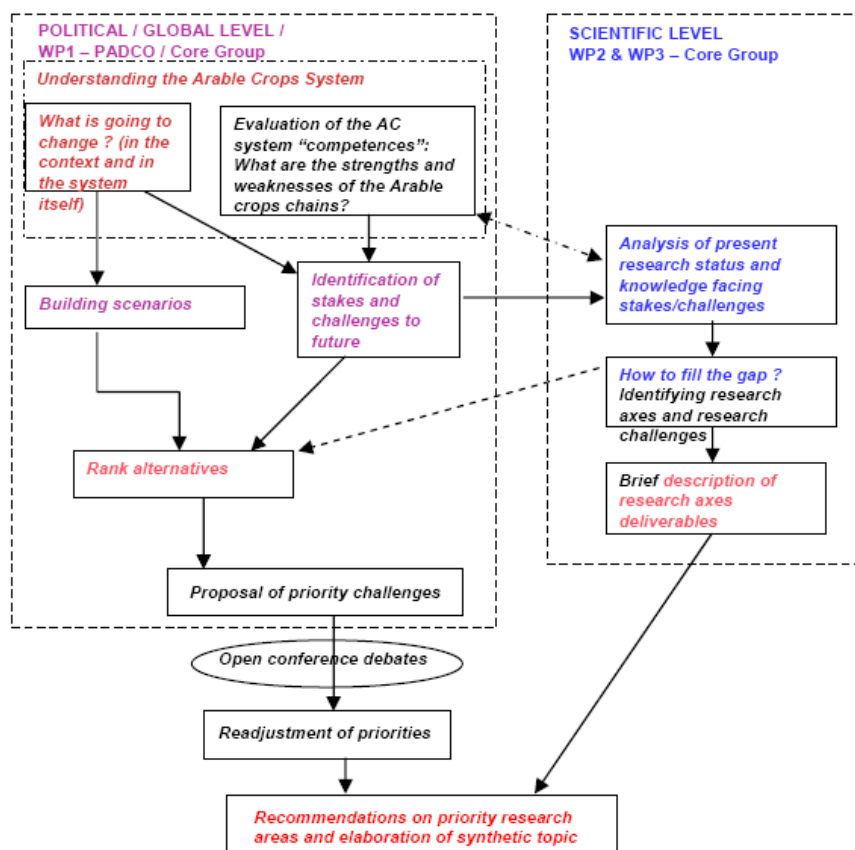


Figure 2: Overview of the methodology/ tasks organisation

This process led to propose priority challenges, chosen for their importance in the majority of the scenarios, or for their key interest in a specific scenario.

The first stage of the workflow consisted in building a consensus description of the arable crop context, by identifying the main factors influencing the AC competitiveness, and feeding a common database on potential future changes and ruptures. On the basis of these hypotheses made on the future behaviour of the factors, the EUROCROP team reached a consensus to consider 4 scenarios, considered as relevant, coherent and plausible. They are not predictive in nature and do not claim to cover all possibilities, but are only thinking frames used in some kind of “stress studies” enabling the determination of the challenges which appear to be common to all scenarios, or part of them, and which challenges appear to be specific to a given scenario or situation, thus helping with prioritisation.

The advantage to this approach is that it allows for the taking into account of several future scenarios and should assist in avoiding critical gaps in decision making and cover a single yet uncertain future.

These scenarios were used to identify priorities among the challenges emerging from the thematic working groups, according to the following process:

a) the challenges were scored relatively to each scenario. For this step, each expert had to dispatch a total of 100 points among the 36 challenges to assess their relative importance in case the scenario were to occur; scores given by all participants were added and transformed into a ranking of priorities;

b) each challenge being characterised according to its rank of priority in the context of the 4 scenarios, major priorities were identified and characterized in importance on a 4 levels scale:

- level 1 (red colour): scored in the top 25% of ranking scores in 3 of the 4 scenarios, and in the top 50% of ranking scores for all scenarios examined
- level 2 (dark purple colour): scored in the top 25% of ranking scores in 3 of the 4 scenarios, or scored in the top 50% for the 4 scenarios
- level 3 (light purple colour): scored in the top 25% of ranking scores in 2 of the 4 scenarios, or scored in the top 50% for 3 of the 4 scenarios
- specific concerns (“wild cards”, bright blue): scored in 1st, 2nd or 3rd position in one of the scenarios (i.e. not considering this challenge could be a fatal mistake if the considered scenario occurs).

At last, an open conference permitted to introduce these priorities to a wider group, which had not participated to the activities of the project before. The contents of the debates among this new panel of experts and stakeholders were taken into consideration, as well as the contents of existing research programmes, to formulate the final recommendations of the project, focussing on 4 major areas for research.

2.3. Organisation of thematic activities

The identification of the priorities at the technical and scientific levels was structured according to the cross-cutting scheme explained in Section 2.2 with each main theme (crop chain approaches or horizontal issues) constituting a work package. These WP were carried out, beginning with the crop chains in WP2 (November 2006 to July 2007) and continuing with the horizontal issues in WP3 (April 2007 to July 2008).

This process enabled feeding the horizontal issue groups with the basic concerns of the crop chains, and undertaking deeper investigations on subjects of common interest in WP3.

Basically, the thinking process was organised through: a) some preparatory work; b) under the responsibility of a working group leader, project partners came together to facilitate the identification of the main challenges and the weaknesses of AC based on the present status of research and knowledge; c) working group meetings bringing together thematic experts to highlight priority challenges and identify related research areas to fill in competitiveness gaps; d) research topic description and identification of deliverables expected in each research area: this work was generally commenced during the expert group meetings and finalised later.

WP2 and WP3 organized 15 and 10 workshops respectively involving a total of approximately 120 experts from a hundred different institutions from across Europe.

The WP2 groups followed a general methodology consisting in an assessment of the present situation of the crop chain in Europe mainly based on the logic of the SWOT Analysis, i.e. the identification of strengths and weaknesses, threats and opportunities, followed by the identification of challenges. This work was carried out on the basis of the common database on potential future changes and ruptures (obtained through the initial activities of the scenarios process) and from the groups' expertise.

Thereafter, the groups sought to relate these challenges to major stakes and translate them into operational goals and research objectives, leading to the building of a tree structure from challenges to specific objectives or deliverables. Propositions for definitions were provided to specify the levels of the future tree structure taking the example of the structure adopted by the European Technology Platform Food for Life, using 4 levels.

The project finally adopted a four levels structure from the strategic level to the detailed research actions, including Stakes (major fields of competitiveness for the AC sector), Challenges (operational objectives of major interest for the AC sector competitiveness), Research goals (questions for research) and research actions.

3. Results

3.1 Scenario approach

The consensus description of the arable crop context was elaborated during the first year of the project. This representation includes 5 external dimensions (Social and economic aspects in the EU; EU outlets and demand; World level markets and trade; Policies and regulations; Environment; Agriculture near context, and rural socio-economics) and 1 internal dimension. These dimensions are used to identify challenges and elaborate scenarios, constituting "visions of the future", and used to elaborate research strategies.

The 4 contrasted scenarios ([3], [4]) elaborated by the project group are:

- **SC1: "WTO agreement and expensive energy"**: a continuation of liberal world market logic: a WTO agreement is reached, the dominant agricultural model is clearly that of productive business agriculture, the CAP is strongly reduced but its main orientations are maintained the economic context remains one of sustained economic growth.
- **SC2: "Europe of regions"**: no WTO agreement is reached, but the dominant logic remains a liberal one with a double regionalisation: bilateral agreements and an increased autonomy for EU regions. The CAP is reduced and decentralized to "regions", on an increased subsidiarity basis. Many agricultural models (led by the environment, leisure and tourism, local agro-industries, energy production etc.), emerge from regional projects and coexist.
- **SC3: "High environmental performance, green Europe"**: in this scenario, public opinion is increasingly concerned with human health and the environment, which in turn becomes major drivers of public policy. The CAP is reoriented to support the "Health & Environment Performing Agriculture" (HEP) model. The context is one of slow economic growth with no WTO agreement.
- **SC4: "Challenge of global warming"**: global warming becomes acute and is a driver of public policy. The CAP is reoriented to meet the triple necessity to "feed the world", produce clean energy and manage natural resources. A WTO agreement is reached.

It is worthwhile noting that the scenario which was considered most probable at the beginning of the group work activity in 2006 is no longer likely in 2008 when the project submitted its recommendations. Accordingly, devising strategies based a sole vision of the future may well prove risky.

3.2 Crop chain approach

Using the general methodology, each crop chain group carried out its own analysis and identified challenges and related operational goals for research, reaching its own internal coherence. Depending on the perception of the complexity of the systems, and of the relative importance of a specific topic for a crop chain, this topic could appear as a "challenge", or simply a goal.

The development of the synthesis of these results required the re-specification of the definitions of the tree structure levels and the harmonisation of the outputs of the different groups, assembling similar needs

or issues emerging from the different crop chains. This synthesis work allowed for the proposal of a first tree structure with 6 stakes, 31 challenges and 74 goals.

This tree structure was slightly modified and reorganized later on to take into account complementary issues from the WP3 groups. At that occasion, stakes 5 and 6 were gathered as “societal sustainability”, and the tree structure was made of 5 stakes, 36 challenges and 105 goals, as shown in Table 1, which shows the first two levels of this tree structure, in which the WP2 groups identified each issue as challenging for their crop chain.

Table 1: Stakes and related challenges: evolution of the structure between WP2 (crop chain groups) and final structure including WP3 works												
	STAKES			CHALLENGES MENTIONNED BY WG (first analysis)/ WP2 reports titles								
WP 3	STAKES & CHALLENGES FOR ARABLE CROPS FINAL LIST	WP 2	STAKES & CHALLENGES MENTIONNED BY WG (first analysis)/ WP2 reports titles	21 Maj or cer eal s	22 Mi nor cer eal s	23 Oil see ds cro ps	24 Su gar be et	25 Fib re cro ps	26 Pot ato es	27 Gr ain leg um es	28 Mai ze	
1.0	TECHNICAL AND ECONOMIC EFFICIENCY OF ARABLE CROP SYSTEMS	1	COMPETITIVENESS IN MARKETS									
1.1	Increase level and stability of yields	1.1	enhance level and stability of yields:	x	x	x		x		x	x	
1.2	Technical and economic optimisation by innovating sustainable Cropping Systems	1.2	costs optimisation and technical efficiency	x	x	x	x	x	x		x	
		1.3	cross optimisation: economic competitiveness through innovating cropping systems	x	x	x		x	x	x	x	
1.3	Adaptation of production systems and crop rotations according to changes in farming framework conditions											
1.4	Managing risks for EU farmers											
1.5	Increasing logistics efficiency	1.4	developing and increasing logistics efficiency	x								
2.0	MEETING DEMANDS ALONG THE VALUE CHAINS	2	SECURING EXISTING OUTLETS and continued demand									
2.1	Increase efficiency of transformation processes	1.5	increase efficiency of transformation processes	x		x		x				
		2.3	developing transformation processes to enhance product quality					x				
2.2	Characterization of quality and standardization	2.8	characterisation of quality and standardisation	x	x	x		x		x		
2.3	Ensuring food safety	2.1	ensuring food safety of AC products	x	x		x	x			x	
2.4	Meeting food and industrial quality standards	2.2	agricultural primary products meeting industrial quality standards	x	x	x		x	x	x	x	
2.5	Maintain quality of products during storage											
2.6	Increasing nutritional value	2.4	increasing nutritional value of AC products	x		x				x		
2.7	Addressing consumer demand in nutrition and dietetics	2.6	addressing consumer demand for healthy food	x		x		x	x	x		
2.8	Understanding and addressing purchaser demand	2.7	understanding consumers' and purchasers' demands	x			x					
2.9	Brand and quality standard protection / To ensure consumer confidence											
2.10	Increasing producer share of any added value											
3.0	NEW OUTLETS AND MARKETS	3	HORIZONTAL EXPANSION: developing new outlets and new markets for arable crops									
3.1	Developing New food uses	3.1	developing New food uses		x		x		x	x		

3.2	Developing New feed uses	3.2	developing New feed uses								x	
3.3	Developing Non food/ non feed uses	3.3	developing Non food/ non feed uses: green chemistry	x	x	x	x	x	x	x	x	
		3.4	developing bio energy equivalent outlets	x	x	x	x	x		x		
3.4	Global optimization of resources (land, biomass, energy) and choices for new productions to develop sustainable and productive territories											
4.0	SUSTAINABLE PRODUCTION and ENVIRONMENT ASPECTS	4	SUSTAINABLE PRODUCTION: environment aspects									
4.1	Improving resource use efficiency: nutrients	4.1	improving resource use efficiency: fertilizers (including nitrogen)	x		x					x	
4.2	Improving resource use efficiency: energy	4.2	improving resource use efficiency: energy	x		x	x					
4.3	Improved resource use efficiency: water	4.3	improved resource use efficiency: water	x			x	x				x
4.4	Maintaining diversity in genetic resources of crops	4.4	maintaining diversity in genetic resources	x	x						x	
4.5	Enhancing biodiversity in agro-ecosystems	4.6	mastering crop impacts on environment and biodiversity	x		x	x	x				
4.6	Ensure an effective crop protection in the long term (integrated crop protection)	4.5	maintaining efficient crop protection over the long term: facing pest & pathogen population evolutions	x	x	x	x	x	x	x	x	x
4.7	Minimize greenhouse gas emissions per unit of product											
4.8	Maintain and improve soil quality											
4.9	Reduce water pollution											
4.10	Developing strategies to face climate diversity and climate change	4.7	improving the physiological plasticity of crops to face climate diversity	x	x	x	x	x	x	x	x	x
4.11	Integrating different sustainability concerns in the design and implementation of innovative cropping systems	4.8	developing innovative sustainable cropping systems	x	x			x			x	
4.12	Developing common sustainability assessment methods	4.9	developing common sustainability assessment methods	x			x		x	x		
5.0	SOCIETAL SUSTAINABILITY	5	SUSTAINABLE PRODUCTION: long term economic aspects. keeping producers producing									
		6	SUSTAINABLE PRODUCTION: crop production SOCIETAL ACCEPTANCE and confidence									
5.1	Improve efficiency in value chain and networking	5.1	developing farmers' security within crops chains: coordination and services to farmers	x		x		x			x	
5.2	Reinforcing entrepreneurship and innovation capacity of AC systems	6.2	improving farmers' training and innovation transfer	x		x						
5.3	Developing income with indirect relations to AC production: income from other activities	5.2	developing crop incomes with direct relation to production	x				x			x	
5.4	Improving the integration of arable crops into rural territories and economies	6.1	improving the integration of arable crops in the economies of rural territories	x							x	
5.5	Promote a consistent regulatory and governance system to strengthen the competitiveness of AC											
5.6	Achieving a positive public perception of arable crops systems	2.5	image: achieving a positive perception of arable crops and arable crop products	x				x			x	

A number of challenges crucial for competitiveness within each crop chain proved to be common for the majority or all of the crop chains. More than half of the challenges identified in WP2 (18 out of 31) were

addressed by at least four crop chains which means they are considered relevant for competitiveness by half of European crop chains.

The two most important challenges turned to be “maintaining efficient crop protection over the long term: facing pest & pathogen population evolutions” and “improving the physiological plasticity of crops to face climate diversity related to environmental aspects of sustainable production”. Only these two issues were identified by all crop chains. They should be connected to a major effect of climate change (expected higher abiotic and biotic stress due to weather patterns) as well as to more limited choice of chemical pest control as a result of tighter regulations. In this situation, enlarging occurrence range by pests due to e.g. increase of average temperature cannot be sufficiently controlled by chemical pest control which obviously causes a concern.

The issues that drew the least attention were identified by one crop chain only. There were two such issues: developing and increasing logistics efficiency, related to stake competitiveness in markets and developing transformation processes related to securing existing outlet and continued demand.

The WP2 work allowed for the specification of goals which represent questions for research. Table 2 provides an example of this level of detail for challenges 1.3 and 1.4.

Table 2: Challenges and goals structure (extract)		
	Challenge / Goal	
1.3	Cross optimisation: economic competitiveness through innovating cropping systems	WG3.1
131	<i>developing precision farming</i>	WG3.1
132	<i>optimising cropping systems with reduced soil cultivation</i>	WG3.1
133	<i>optimising labour management</i>	WG3.1/WG3.2
134	<i>optimizing crop rotations</i>	WG3.1 + other
1.4	Developing and increasing logistics efficiency	WG3.2?
141	<i>predicting harvest and quantities</i>	?
142	<i>improving storage efficacy</i>	WG3.4?
143	<i>improving batching and marketing</i>	?

3.2 Horizontal issues

The main result is the elaboration of 73 research topics (see annex).

WG3.1 “Technical aspects at farm level” developed a longer list of topics compared to the other WGs. This reflects the variety of agronomic and climatic conditions, as well as the different technologies involved in the process of production at the farm level highlighted in the preliminary analysis. The emphasis is on genetics and breeding as tools to produce suitable plants, and rotations and techniques as means to combine such plants in efficient systems. Two main concerns dominate: a) management and sustainability of plant protection; and b) efficient use of resources (land, water, fertilisers). The issues raised already extensively incorporate environmental concerns.

WG3.2 “Farm economics and production costs” addressed the economic aspects of the nearest context related to farm level operations. Most of the topics concern mechanisms of adaptation to external drivers, such as climate change and market prices. An important focus that also attracted attention in WG3.1 and 3.6 is the issue of risk management in a context characterised by increased price volatility and uncertain environmental (climate) conditions.

WG3.3 “Outlets and markets” addressed the three main areas of food, feed and non-food/non feed; however, at the end of the topic elicitation and description process, overall optimisation and systemic improvements dominated this group. This is partially due to the interpretation of the role of the WG (downstream connections of arable crops and not the processing industry *per se*), and partly due to the understanding that the opportunity for major improvements already exists in the system through an improved combination of existing processes and technologies.

WG3.4 “Quality of agricultural products” focus on a range of issues that connect quality with aspects of other WGs (such as agronomic or consumer research). Genetics again play a major role here, including the explicit consideration of the issue of GM crops.

WG3.5 “Environmental impacts” addressed the variety of environmental concerns related to agriculture and AC in particular. Some of these show close connections with agronomic priorities for research, emphasising the aspects connected to agriculture. Some of these focus on the environmental benefits arising from the appropriate management of arable crops, such as contributions to soil protection and biodiversity.

WG3.6 “Socio-economic issues” complements the topics of WG3.2, whilst focusing on the wider context. Adaptation and innovation processes, and the ability to respond to quality of life issues are the dominant themes. Different topics emphasise the fact that AC producing agents are part of a wider system, and human actions (as well as, or even more than, crop life) require an understanding and appropriate feed-backs within such a system.

In the final output of the horizontal groups, we observe that the needs expressed by crop chain groups (mainly led by both technical and economical considerations and benefits for producers, with accompanying scientists) or by horizontal issue groups (more oriented on knowledge gaps and scientific considerations, and benefits for society, on the basis of the preliminary analysis by the crop chains groups) are slightly different.

In fact, we observe that only 6 challenges over 36 identified all along the process are not directly covered by the WP3 topics. These challenges are (1.5) increasing logistics efficiency, (2.5) maintain quality of products during storage, (2.9) Brand and quality standard protection, to ensure consumers’ confidence, (2.10) increasing producers’ share in added value, (3.1) Developing new food outlets, (4.4) maintaining diversity in genetic resources of crops. Furthermore some challenges are better covered than others (from 0 to 5 topics per challenge)

However, at the level of goals, we observe that only 58% of goals (over 110) were developed through one or several research topics, as shown in table 3, while some goals are covered by 2 or 3 topics.

Table 3: correspondence between goals and research topics.

Stakes	Number of goals	Number of topics			
		0	1	2	3
	total	0	1	2	3
Stake 1	16	7	6	2	1
Stake 2	22	11	9	2	0
Stake 3	15	9	5	1	0
Stake 4	47	22	19	5	1
Stake 5	10	3	3	2	2
TOTAL	110	52	42	12	4

3.3 Priorities in challenges

The 36 challenges, once consolidated to take into account WP2 and WP3 issues, were scored according to the 4 scenarios. The results emerging from the project activities are summarised in table 4 and include the highest 50% priority challenges (18 of 36 challenges).

Four challenges appear as first level priorities for the sustainability of AC system competitiveness:

- a) food safety, which is a basic need of populations;
- b) the maintenance of an efficient crop protection, as a major guarantee for food security;
- the improvement of resource use efficiency: c) energy and d) water, of both short term economic interest and a fundamental issue for long term sustainability.

The second level includes 4 supplementary challenges where economic competitiveness is predominant, dealing with yield level and stability improvement, optimisation of cropping systems and adaptation of production systems, and nutrient use efficiency (long term sustainability issue).

Four of the third level priorities could be considered as secondary levers of competitiveness: managing risks for farmers (risks related to markets, climate variations...), developing non-food non-feed uses, developing entrepreneurship and innovation capacity, developing a positive public perception of AC.

The two other ones are related to sustainability aspects and future capacity of agriculture: developing sustainability assessment methods is a basic need for both the ex-ante and ex-post evaluation of actions on AC systems; and at last, the issue of soil quality, often neglected when dealing with competitiveness, is a growing preoccupation from a heritage perspective.

“Wild cards” concern three main issues:

- The first is the integration of arable crops in rural territories, that appears as essential in scenario 2, where competitiveness is determined at regional level, but it should be considered that meeting this challenge could contribute to other political objectives, rural development being the first one.
- The two other “wild cards” are key issues for scenario 4, related to climate change: to mitigate its effects and minimize a further degradation of the situation.

Table 4: Common challenges in all scenarios

		SC. 1	SC. 2	SC. 3	SC. 4	COMMON
	CHALLENGES FOR ARABLE CROPS	Rank of priority (over 36 chal.)				
1.1	Increase level and stability of yields	1,0	4,0	18,0	11,0	☆☆
1.2	Technical and economic optimisation by innovating sustainable cropping Systems	8,0	6,0	11,0	6,0	☆☆
1.3	Adaptation of production systems and crop rotations according to changes in farming framework conditions	16,0	15,0	17,0	14,0	☆☆
1.4	Managing risks for EU farmers	18,0	12,0	29,0	15,0	☆
2.3	Ensuring food safety	7,0	3,0	3,0	12,0	☆☆☆
3.3	Developing Non food/ non feed uses	12,0	23,0	14,0	13,0	☆
4.1	Improving resource use efficiency: nutrients	4,0	25,0	2,0	8,0	☆☆
4.2	Improving resource use efficiency: energy	2,0	10,0	2,0	4,0	☆☆☆
4.3	Improved resource use efficiency: water	3,0	16,0	4,0	3,0	☆☆☆
4.6	Ensure effective crop protection in the long term ICP)	17,0	2,0	1,0	5,0	☆☆☆
4.7	Minimize greenhouse gas emissions per unit of product	33,0	33,0	9,0	2,0	♣
4.8	Maintain and improve soil quality	29,0	17,0	6,0	10,0	☆
4.10	Developing strategies to face climate diversity and climate change	36,0	35,0	15,0	1,0	♣
4.11	Integrating different sustainability concerns in the design and implementation of innovative cropping systems	28,0	12,0	11,0	9,0	☆
4.12	Developing common sustainability assessment methods	35,0	24,0	8,0	6,0	☆
5.2	Reinforcing entrepreneurship and innovation capacity of AC systems	8,0	8,0	29,0	22,0	☆
5.4	Improving the integration of arable crops into rural territories and economies	19,0	1,0	21,0	33,0	♣
5.6	Achieving a positive public perception of arable crop systems	23,0	8,0	16,0	18,0	☆

3.4 Major topics

The list of topics identified in WP3, resulted rather long having the advantage of a wide coverage but also the disadvantage of an insufficient focus. Furthermore, the final recommendations of the project had to take into consideration 1/ the priorities made on the basis of the challenges for AC, 2/ the elements of the debates with the stakeholder roundtable held in the EURO CROP final conference.

For this reason the core group of the project decided for another step, aimed at providing the identification of a limited number of research areas to be considered as high priority. In the first step, the core group voted about the priority to be given to each topic in the full list developed in WP3. In a second step, the selected topics were used as core issues around which to aggregate selected contents from neighbouring or complementary topics.

Considering the 73 research topics and the priority challenges, the major topics for research identified are A: Risk management and adaptation of arable farming; B: Innovation in cropping systems for high environmental and economic performances; C: Limiting the impact of arable crop cropping systems on green-house gas emissions; D: Better understanding of public concerns about arable crop production and products and communication with global and local society.

Furthermore, the project recommends going on investing in food safety and in integrated crop protection, which are major conditions of competitiveness from both economic and environmental points of view, as it is currently done in several European collaborative research programmes.

4. Discussion

4.1 Model of competitiveness:

Considering the arable crops sector competitiveness and the issues raised in the crop chains groups and completed in horizontal approaches, we may connect the Porter's competitiveness force (1) with the production costs aspects (use of expensive inputs) and (2) with the necessity to enhance yields and produce in a profitable way at world market prices levels. These two points are closely related to the stake 1, initially named "competitiveness on markets" and later changed to "Technical and Economic efficiency of AC systems". The power of customers (3) is considered through the stake 2 initially named "Securing existing outlets" and later changed to "Meeting demand along the value chains". The substitution products (4) are taken into account in the stake 3 "horizontal expansion", renamed as "new outlets and markets", but in a vision more offensive than defensive: arable crops products have no real competitor as substitution on food markets at large scale, but may pretend to replace petroleum based products for specific uses. The power of regulations (5) was specially connected to the environmental regulations in Europe (and agricultural supports submitted to environmental compliance of agricultural practices) and with the specific role of agriculture in this field. (Stake 4, Sustainable production and environment aspects). At last the internal competition (0) between European producers and between agro-products, was connected to a stake 5 "sustainable production, keeping producers to produce". This means that in fact research can contribute to all the main dimensions of competitiveness; however, taking the list of major topics, consumer/citizens acceptance has been fully considered as a field of major interest for future competitiveness. In fact, 51% of the topics are focussed to economic competitiveness, 19% to purely environmental and social issues, and 30% present interest for both, economic and environmental/social issues linked to consumer/citizen acceptance.

The Porter's model of competitiveness is coherent with the issues raised by the crop chain working groups, organised as stakes/challenges, but appears not sufficient to cover the EUROCCROP vision of competitiveness, which takes into account a growing pressure of the public opinion concerning the impacts of the farming activities on environment and health. The legitimacy of public supports lies in the notion that public goods are produced by the sector, and the growing tendency is that agriculture is now not predominantly perceived as producing a fundamental private good with attached major public goods characters (food), but as being prejudicial to the environment and as a source of food safety problems. Even though the recent food crisis may temperate this vision and whether these allegations are true or not, the social acceptance aspects became a real field of competitiveness which might again grow in importance at the favour of climate change issues. It is the reason why "Societal sustainability" (initially "Societal acceptance") has been considered as a specific stake for EUROCCROP.

4.2 From "questions to research" to "research topics":

EUROCCROP was designed to organise a continuous thinking process from the identification of the socio-economic needs to the specification of research topics. The main difficulty of such an exercise consists in assembling different types of high level expertise and in organising their interactions: socio-economic expertise and intimate knowledge about the organisation and functioning of crop chains is needed to identify properly the challenges and goals to be achieved, when high level scientific expertise is needed to identify the real knowledge gaps, and what depends on new research activities or on development and transfer.

All working groups were supposed to carry out the whole process: from appropriating a basic vision of the context and completing it to making their own interpretation as challenges and then as research gaps and topics. A major characteristic of the methodology was the principle of two successive working phases by crop chain and then by horizontal topics. For crop chains working groups, the WG leaders were predominantly experts of crop chains, involved in applied research, transfer and development aspects, coming from professional organisations and institutes. For horizontal issues working groups, WG leaders were scientists from public research institutions, with a wide understanding of the thematic issue. The experts who participated to the working groups were predominantly scientists or applied scientists.

The results of the process show that the crop chains working groups quite easily adopted the proposed methodology and organised their proposals according to a tree structure based on the identification of challenges, operational goals and actions, which fits well with a thinking process based on strategic gaps. The main difficulty was encountered to compare and aggregate the outputs of the 8 groups, due to

different ways of approaching the problems, from very globally to quite detailed. The common structure as challenges, research goals and actions had to be rebuilt, synthesising the ideas coming from the different groups. The second difficulty lay in dealing with the multiple contribution of an elementary action to several goals or challenges. At that moment the team got around this problem by repeating the ideas in the tree structure or by making choices according to major contributions. This solution revealed to be relevant at this step of the work only: in fact, the single meeting of crop chain experts only permitted to identify titles of actions or goals, which constitute a number of questions to research, but was insufficient to reach the description of research topics.

The horizontal issues groups integrated this basis and enlarged it when appropriating the context elements: some new challenges and goals were added, answering specifically horizontal issues (see table 1). During this phase, the total number of challenges increased from 31 to 36, and the number of goals from 76 to 110, some items of the initial list being renamed or gathered with others.

On this basis, the works went on with the elaboration of research topics, focussing on the knowledge gaps and on the scientific coherence. This second step of the work was permitted by the possibility to hold a second meeting, and by extra works.

We observe that among the 52 goals which were not developed as research topics, 30 come from crop chains groups and 22 from horizontal issues groups. The origin of the idea – whatever it emerged in crop chain or horizontal groups – is not determining in the later selection process to elaborate research topics..

On the contrary, we sorted the topics according to the nature of their orientation:

- 35 are focussed on finding solutions aiming at immediate applied needs, with applied results expected in the project duration;
- 5 call for research aimed at achieving basic knowledge and focus on understanding specific aspects in order to identify future solutions (in the fields of genetics of plants and pathogens, human nutrition, and soil sciences (biological aspects);
- 35 call for “system explaining research”, focussed on understanding the functioning and behaviour of the system(s) in order to identify future solutions;
- 4 ask for coordination action targeting the coordination of current research and development activities, and the specification of new research activities.

Among the 52 goals not developed as topics, 38 would have fell in the first category, 12 in the second one and 3 in the third one. It means that about half the identified needs concern immediate applied needs, but only half of these applied needs have been considered as priorities for research. On the contrary, 30% of the identified needs fall in the third category (systemic approaches), but the majority of them has been developed as research topics. The second category (basic knowledge) represents 13% of the identified needs, but 70% have been developed as topics. Nevertheless, almost half of the topics is focussed on immediate needs and applied results

The categories of applied needs which were not developed as research topics are linked to:

- the innovation in inputs (varieties, pesticides, equipments and technologies), which constitute the main field of innovation of private companies (but some needs related to the good use of these innovations have been treated as research topics);
- logistics of crop chains;
- quality and safety management;

These categories are related to technological innovation, organisation and chains management. Two reasons could explain they have not been treated: 1/ these preoccupations could be considered as fields of investment for the crop chains themselves, 2/ the panel of experts lacked competence in these matters.

Considering the results of the whole process, we may conclude that the methodology allowed a real and satisfying interaction between the socio-technical expertise (involved mainly in crop chain groups) and the specialized scientific expertise, permitted to reach a balanced expression of immediate applied needs of agricultural production and longer term system management and to show objective links between research orientations and challenges for AC sector. But technological innovation remains insufficiently explored.

4.3 Comments on the nature of identified topics

The results reflect a situation in which systemic knowledge, which implies multidisciplinary approaches, remains the main bottleneck to progress in the field of agronomic sciences and arable crops, and a major challenge for research and research institutions.

The systemic approaches proposed in the topics cover many sub-systems of the AC system in relation with its context:

- crops (plants) in relation with their biological environment (pathogens, pests and weeds, other crops, general biodiversity...);
- crops (plants) in relation with their physical environment (soils – physical characteristics and fertility - climate...), with sub-systems related for example to carbon and to nitrogen cycles aspects (fertility *and* green house gas emissions);
- arable crops in the territories (competition for land uses, including urban extension, natural resources management, relations with animal productions...);
- arable crops in the socio-economic context (social benefits, acceptance...);
- crop chains systems: relations between the crop chains actors (cooperation, sharing added value...);
- agro-industrial system (crops quality and industrial processes).

At last a specific topic deals with “scaling issues, find sustainable solutions at different scales”, which targets a coherent approach of interlocked sub-systems.

The exceptions where basic/fundamental research is specially identified in the WG proposals are the fields of genetics (plants and pathogens), human nutrition, and, to a certain extent, soil sciences (biological aspects).

Almost half the topics are focussed on immediate needs and applied results: this is a quite satisfying ratio to address sector competitiveness at relatively short term (2015). These topics reflect the fact that already a large amount of basic knowledge is available for action, but that applied research has still to be organised to make it efficient for the competitiveness of the sector.

Concerning the 4 major topics, the full set is well distributed between economic competitiveness concerns (topics A and B) and compliance aspects (topics B, C and D). Topic D could also be considered as economic competitiveness if we consider the aspect of the perceived legitimacy of public supports to AC. The major point to underline is that these 4 topics (and integrated crop protection too) necessitate systemic and multidisciplinary approaches to explore different systems in which AC are included (A: markets, B: cropping systems and production basins, C: atmospheric system (and nitrogen cycle), D: “global village”). It means that, from the point of view of the evolved European agriculture, the main field of competitiveness, progress and innovation is now at systems scales, much more than on elementary techniques.

At the opposite, the project also confirms that a number of well established research topics retain their importance (e.g. yield improvement, plant protection) and must be considered as fields of continuous progress. However, they require cautious coordination with an increasingly complex system of short term priorities.

4.4 Relation between EUROCCROP topics and existing research projects

A systematic comparison between the EUROCCROP topics and ongoing projects was carried out. Only 27 out of 73 topics were found to show similarities or overlapping with already existing research projects from the 6th Framework Program, hence demonstrating that there is a wide scope for increasing responsiveness between research and AC sector needs. This can go as far as emphasising the need for different EU research strategies for AC.

Conclusions

The exercise carried out in this paper and throughout the project EUROCCROP shows the relevance of a continuous re-thinking of research priorities at sector level, as a complementary activity to those already carried out concerning the whole EU and world agriculture (e.g. SCAR). Sectors-specific attention allows both a better connection to a strategic view and a more detailed identification of research topics.

The exercise also emphasise the extreme speed (and some unpredictability) of change of the surrounding context, highlighting the need to connect the identification of research priorities to a clear view of the

future scenarios and to provide a regular re-thinking of the research priorities, even also to confirm those that maintain their relevance over time. In this sense the EUROCCROP exercise provides a systematic basis for a regular revision and update.

This exercise also demonstrates the strategic interest in organising interactions between economic actors, scientists and stakeholders, according to a methodology which allows distinguishing and connecting several levels of expertise and exchange. This methodology could certainly be improved through two ways: 1/ a greater attention to the objectification of the nature and fields of competence of the experts, offering the possibility of a better reactivity to complete the panel during the programme, and 2/ a greater attention to the innovation process (and actors of innovation) beyond the research and knowledge aspects.

While focusing on research needs, the project also allows the identification of gaps and needs beyond such area. In particular, the need for a better understanding of (and coordination with) research capacities and technology transfer systems appeared clear throughout the project.

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Annex - Full list of topics

From WG3.1 "Technical aspects at farm level"

1.01 Increasing yield potential of varieties by breeding for tolerance to abiotic and biotic stresses; 1.02 Improving control on Weeds/Pests/Diseases through better crop rotations, alternative crops and cropping systems; 1.03 Increasing yield stability through genetic resistances to crops enemies (weeds, pests and diseases) based on breeding; 1.04 Production of varieties tolerant to drought, N deficiency, weeds, pests and diseases through understanding crops reactions to stress and tools for breeding; 1.05 Avoiding compaction and reduce soil erosion; 1.06 Develop crop and farming systems capable of improving soil chemical properties (organic matter, salinisation); 1.07 Improve soil biological properties: increasing soil biodiversity by adequate cropping systems; 1.08 Improving water use efficiency of crops: varietal evaluation and breeding; 1.09 Water efficient cropping systems through improved crop mix and irrigation management; 1.10 Sustainable irrigation in relation to water and soil (drainage, salinisation); 1.11 Reducing greenhouse gas emissions of cropping systems; 1.12 Evaluation of different farm types concerning the sustainability of their cropping systems; 1.13 Forecasting of pests and diseases taking into account cropping and management system and crop canopy sensibility; 1.14 Preserving the durability of crop protection means; 1.16 Optimizing crop rotations in reduced or no tillage conditions; 1.17 Management of crop rotations aimed to prevent and control weed infestation, disease and pest infection; 1.18 Anticipating/forecasting the changes of climatic conditions and their effects on crops; 1.19 Innovating for improved energy efficiency of cropping systems; 1.20 Understanding and calculating energy costs in crop chains and at farm level through new methods and references for energy balance of cropping systems; 1.21 Breeding for crop species with improved N uptake and nitrogen efficiency; 1.22 Developing reduced nitrogen input and productive cropping systems: nitrogen optimization at cropping system scale; 1.23 Better use of manures: treatment, application, timing.

From WG3.2 “Farm economics”

2.01 Production systems and rotations: impact of increasing commodity and inputs prices on production systems; 2.02 Economics of farm size: economies of farm size under changing market and policy conditions with focus on new member states; 2.03 Adopting consistent policies: designing improved contractual options to allow flexible access to land for farming in the new Member States (MS); 2.04 Economics of adaptation to climate change; 2.05 Establishment of a common methodology for the quantification of the carbon footprint to compare production systems in selected regions of Europe; 2.06 Economics of straw removal: identify different local conditions for straw removal in Europe and analyse their impact on supply costs; 2.07 Establish competitive crop rotations for bioenergy: analyse the contribution of different crops and crop rotations to bioenergy yields and their economic and ecological impacts in selected regions of Europe; 2.08 & 1.15 Risk management and adaptation of arable farming under price volatility and climate change; 2.09 Researching new activities and possibilities for farmers in the new market situations and new tools for rural development.

From WG3.3 “Outlets and markets”

3.01 Optimising AC for the development of new healthy products; 3.02 Optimising AC for optimal utilisation of nutrients in human and animal nutrition and/or utilisation of components of AC or by-products of food processing for non-food applications; 3.03 Preventing safety risks in arable crops; 3.04 Whole crop utilization; 3.05 Strategies to enhance nutritional quality and processability of crop products and by-products from food industry, bioenergy or biorefinery to secure supply to the European feed sector; 3.06 Improvement of competitiveness of crop production on the global feed and related markets: strategies for competitive EU feed production; 3.07 Science-based integration of feed crops and related animal products in consumer health concerns; 3.09 Land use optimisation for Non-food/Non-feed, Food and Feed, and synergies between production and services in the EU, regional and farm scales; 3.10 Sustainable whole crop use optimisation for non-food/non-feed, food and feed, and synergies between different outlets; 3.11 Agro-industrial parks and land use: closing the regional mass and energy cycles integrating agricultural production, processing, mass flow and logistics and providing balanced services to society

From WG3.4 “Quality”

4.01 Better understanding of the genetic determinants of quality traits to help develop better cultivars capable of delivering required quality in the face of abiotic stress; 4.02 Better understanding of the interaction between processing methods and nutritional quality of produce in order to optimise bio-availability; 4.03 Development of co-existence strategies for EU arable crops with GM and non-food crops; 4.04 Better understanding of the interaction between crop quality characters and processing, to identify areas for improvement and development; 4.05 Development of pest and disease control measures to protect and enhance product quality; 4.06 Develop and improve carbon footprints for EU produce and develop agreed standard methods for their determination across Europe; 4.07 Better understanding of public concerns associated with GM technologies to help shape communication strategies; 4.08 Development of information transfer programmes to increase production and use of EU-derived plant proteins; 4.10 Optimise the digestibility of plant proteins in animal diets

From WG3.5 “Environmental issues”

5-1.1 Environmental and economic optimization of (low-input) cropping systems; 5-1.2 Use of new technologies/methods to increase the efficiency of crop management; 5-1.3 Linking arable crop production to livestock farming; 5-1.4 Physical, chemical and biological aspects of integrated soil protection; 5-2.1 Designing and testing water efficient cropping systems in a multi-scale approach; 5-2.2 Global assessment of N emissions of cropping systems; 5-2.3 Integrated assessment of management strategies for different climatic scenarios; 5-3.1 Efficient biodiversity enhancement; 5-3.2 Integrated and novel approaches for effective crop protection strategies; 5-3.3 Deal with new and emerging pathogens (pests, diseases, weeds); 5-3.4 Scaling issues: find sustainable solutions on different scales; 5-3.5 Evaluate the best regions for crop production

From WG3.6 “Socio-economic issues”

6.01 Definition of services for improving farmers’ orientation, sensitiveness and adaptability to the market; 6.02 Designing EU policy for improving arable crop competitiveness in consideration of globalization and the main uses of crops: food, feed, energy, biomaterials.; 6.03 Deprivation and quality of life in rural areas: provision of public and social goods and services; 6.04 Connection between land consolidation and arable crops; 6.05 Comparative analysis and identification of the innovation opportunities and barriers to increasing efficiency in the arable crop chains and networks; 6.06 Structure and interaction between arable crops and urban planning; 6.07 Open innovation; 6.08 Analysis of farmer awareness of market trends and identification of knowledge gaps; 6.09 Analyze factors serving to promote entrepreneurship at EU level; 6.10 Analyze trust throughout value chains and networks related to arable crops; 6.11 Value chains and networking: analyze value chains and market power.